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A STORAGE STUDY OF SIX COMMERCIAL SOY PROTEIN INGREDIENTS COMBINED WITH GROUND BEEF

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UNITED STATES ARMY
NATICK RESEARCH and DEVELOPMENT COMMAND
NATICK, MASSACHUSETTS 01760

Food Sciences Laboratory

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SOY PROTEIN EXTENDERS	ACCEPTANCE
TEXTURED SOY PROTEINS (TSP)	COOKING LOSS
SOY PROTEIN CONCENTRATES (SPC)	SHEAR VALUES

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This study was designed to provide information for decisions on: (1) the general suitability of soy protein extenders for military use in a frozen ground beef patty vehicle, based upon various objective and subjective indices of quality over time of frozen storage; (2) the feasibility of preparing purchase specifications for ground beef premixed with these extenders; and (3) the advisability of a follow-up production engineering test to include military food service personnel and consumers.

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PROXIMATE COMPOSITION	FROZEN STORAGE
MINERAL ANALYSES	SPECIFICATIONS
VITAMIN B – COMPLEX	FORMULATIONS
TBA ANALYSES	HEDONIC SCALE

20. Abstract (cont'd)

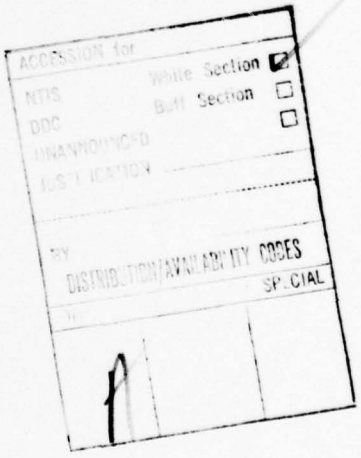
Ground beef patties containing 0 (control), 20 and 30% levels of 6 commercial soy ingredients (4 textured flours and 2 concentrates) were prepared according to Military Specifications. Consumer-type evaluations were conducted initially and after 3, 6 and 9 months frozen storage, using the Hedonic scale to measure overall acceptance. The patties were grilled 3 minutes per side at 176 C from the frozen state and presented to judges with optional salt, catsup and relish accompaniments. Objective determinations on raw patties included the following: proximate analyses of moistures, protein, fat, ash, and NaCl; analyses of selected minerals; B-complex vitamins; and TBA rancidity index. Total cooking loss and shear determinations were made on cooked patties.

Averaged across storage times and sources, the zero levels controls were significantly more acceptable than the 20% levels which in turn were significantly higher than the 30%. Acceptability of the initially evaluated patties was significantly higher than for those evaluated at all other storage times, with no further decrease in acceptability after 3 months. The textured flours were rated somewhat higher than the concentrates. Patties containing soy extenders were similar to the controls in proximate, mineral, vitamin B-complex and TBA analyses. In addition, no notable changes over time of frozen storage occurred. Substantial reductions in total cooking losses and shear values were attributed to the presence of soy extenders.

Preface

This study was financed with O&MA funds under DoD Production Engineering in Support of the Stock Fund, Food and Food Service Items. It was initiated by Dr. Maxwell C. Brockmann, retired, formerly Chief, Animal Products Branch, Principal investigator was Dr. Larry C. Hinnergardt now with Chesebro-Ponds, Inc., Trumbull, CN 06611. Beef patties for the study were procured through Project Order 72-192 with the USDA Agricultural Research Service, Marketing Research Institute, Beltsville, MD, who conducted independent concurrent studies on the same lots that included extensive sensory panel examinations and objective indices of quality.

The authors express their appreciation to the following for their assistance with this study: (1) CPT Gary T. Burger, formerly of the Animal Products Branch, Food Technology Division, FEL, for handling withdrawals and performing objective measurements; and (2) to the staff of the Food Acceptance & Food Senses Group, Behavioral Sciences Division, FSL, for conducting sensory panels and analyzing data, and (3) to Stuart J. Zakon, Summer Aide with the same Group, for preparing tables containing analytical data.



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INTRODUCTION

As of 1973, little sensory or compositional data was available on ground beef extended up to 30 percent with textured vegetable protein ingredients. Such ingredients, however, had already been approved for use in the Type A School Lunch by the Food and Nutrition Service, United States Department of Agriculture.[1]

Previous studies have considered the effects of low level soy ingredient additions on various subjective and objective criteria. Using a two percent toasted soy grit level in ground beef patties, Huffman and Powell[2] found that, at three initial fat levels, Allo-Kramer shear values were significantly lower than the control patties. At the same time, their sensory panel, using the criterion of resistance to chewing, rated the soy-added patties significantly higher than the control patties at the two lower of the three fat levels. This was interpreted as indicating that patties containing the soy ingredient were more acceptable. There were no significant textural differences between patties cooked from the frozen or thawed state when ratings were averaged across soy ingredient level.

Nollman and Pratt,[3] working with meat loaves, found no significant sensory differences between a two percent textured soy protein (TSP) addition and the control condition. Here, the hedonic scale and a trained panel were used to rate texture, juiciness, and flavor criteria.

An important criterion for acceptance of new foods and ingredients into U.S. Military Subsistence systems is storage life. No data exists to date on the effects of soy ingredient extenders on beef patties held frozen. The stability of beef fat and certain vitamins in

[1] United States Department of Agriculture, Food and Nutrition Service, FNS Notice 219, February 1971.

[2] Huffman, D. L. and W. E. Powell, 1970. *Fat content and soy level effect on tenderness of ground beef patties.* Food Technology 24:1418.

[3] Nollman, D. S. and D. E. Pratt, 1972. *Protein concentrate and cellulose as additives in meatloaves.* J. Amer. Dietetic Assoc. 61:658.

the presence of the soy protein extenders also is not known up to and beyond the current six-month expected storage life of beef patties. Effects of the maximum permitted levels of extenders on consumer-type sensory judgments or on objective quality indices, such as shear values, need to be described.

Beef patties are a heavily used, and relatively expensive product in military food service systems. When price differentials are favorable, the use of vegetable protein extenders could have a significant effect on procurement costs. This study, therefore, was undertaken to provide the data base needed for decisions on (1) their general suitability for future military use, (2) the feasibility of preparing specifications for procuring ground beef with added extenders, and (3) whether or not to proceed with a production engineering test with military food service personnel and consumers.

MATERIALS AND METHODS

Ground beef patties were procured through Project Order AMXRED 72–192 with the USDA Agricultural Research Service, Marketing Research Institute, Beltsville, MD. The U.S. Army Research & Development Command (NARADCOM) received 13 lots of beef patties: one lot was a all-beef control; eight lots were extended with four commercial sources of textured soy protein (TSP) at 20 and 30 percent levels; and the final four lots were extended with two commercial sources of granular soy protein concentrates (SPC) at the same two levels. One-half of each lot was allocated to the USDA Meat Science Research Lab, ARS, Beltsville, MD, for experiments similar to those performed at NARADCOM.

All patties were processed using commercial-scale equipment at the Esskay Packing Company, Baltimore, MD, according to the Type II category of Military Specification MIL–B–003854F; Beef, Ground, Frozen. Packaging was at Level C of the specification. Ground beef to be extended with the hydrated soy protein was nonconforming with respect to fat content; the level was adjusted to a calculated 28 to 31 percent so that with addition of the soy ingredient it would reach a calculated final fat level of 19 to 22 percent.

Calculated extender levels analyzed fat in raw ground beef before addition of extenders, and formulas for each lot of patties are given in Appendix A, Table 1.

Beef was first ground through a 2.5-cm plate, mixed with the hydrated soy protein extender, then reground through a 0.3-cm plate. Approximately 85-gm patties were formed, interleaved with freezer paper, boxed, and placed in a −24°C blast freezer until the box center temperature was approximately −18°C. They were shipped to the two laboratories and held at the latter temperature until evaluation.

Soy protein sources comformed to USDA/FNS Notice 219. Commercial sources of the TSP extenders, all containing about 50 percent protein, were: Swift, Pfizer, Cargill,

and Archer Daniels Midland (ADM). SPC extenders were obtained from Swift and Central Soya and contained about 70 percent protein according to technical specification literature provided by the vendors. Proximate and selected mineral analyses are given in Appendix A, Table 2 and indicate that the TSP extenders were essentially as described by the vendors. However, the SPC extenders had somewhat less than the expected protein levels.

For sensory evaluation of acceptability, 35-member consumer-type panels were randomly drawn from a pool of about 500 NARADCOM employees. Evaluations were held shortly after receipt of the beef patties (initial tests) and after 3, 6, and 9 months storage at −18°C. Three test sessions were required at each withdrawal. Each session consisted of an all-beef control and patties containing two randomly selected TSP and/or SPC extenders at both 20 and 30 percent levels. Since a control was included in each session, the same lots of samples were evaluated with each other for the remainder of the study. Patties were grilled on a 176°C surface, three minutes per side. Although cooking was on an "as needed" basis, a brief hold in a 65°C water bath was required. Whole patty samples were served in balanced random order without buns but with optional salt, catsup, and relish. Condiment usage was recorded at each session. Method of measurement was the nine-category hedonic scale. Concurrently with the sensory tests, samples from all-beef patty lots were analyzed for moisture (1) and the TBA rancidity test of Parladgis, et al.[4] At 0 and 9 months, each lot was also analyzed for percent moisture, fat, protein, ash and NaCl; in addition, mg/100 gm of Ca, P, Fe, Na, K, and Mg were determined. The soy extenders were also analyzed for these components.

Random samples were selected from each lot of frozen raw patties and sent to Shankman Laboratories, Los Angeles, CA, for analysis of B-complex vitamins. Percent total cooking loss and Allo-Kramer shear press measurements were made on 20 randomly selected patties from each lot. For cooking loss determinations, the frozen raw patties were weighed, grilled for 3 minutes per side at 176°C, drained for one minute and re-weighed. The same patties were then cooled to 4.4°C and sheared with the standard 7-blade cell of the Allo-Kramer shear press.

RESULTS AND DISCUSSION

Subjective Data

Summaries of sensory panel acceptance data are presented in Appendix A, Tables 3 and 4. Table 3 indicates that control patties were rated higher than those containing 20 or 30 percent additions of TSP or SPC. The statistical significance of this main effect,

[4]Parladgis, B. G., B. M. Watts, M. T. Younathan and L. Dugan, Jr., 1960. *A distillation method for the quantitative determination of malonaldelyde in rancid foods.* J. Amer. Oil Chem. Soc., 37:44.

however, was nullified by a significant level-source interaction which, as shown in Table 4, was eliminated when the analysis of variance was computed without the control patty data. The recomputation also yielded mean ratings across both use levels of the six extender sources that were not inflated by control patty ratings. One TSP, the ADM, emerged significantly ($p < 0.01$) more acceptable than the other TSP and SPC extenders. In general, patties containing SPC extenders were less acceptable than those containing TSP, which was indicated by both summary and individual session data in Appendix A, Table 5, Sessions I and III.

The effect of storage time on acceptability was negligible over the nine months of the test, as may be observed in both summary and individual session data. Although there was an apparent significiant main effect of storage time between the initial and three month evaluations, it was nullified by a significiant source-time interaction which remained when the analysis of variance was recomputed without control sample data. Even if the drop in ratings over time had been statistically significant, the practical significance would have been questionable since differences between withdrawals were small. In another statistical analysis, storage time was found to account for only 0.7 percent of the variance components of the sensory panel data.

Apparent throughout the series of tests was the variability in ratings for the control patty as indicated in Appendix A, Table 5. This could have contributed to the significant level-source interaction. This variability may be explained in part by data in Appendix A, Table 6 wherein one-third to one-half of the judges in each session voluntarily commented on "toughness" and "rubberiness". However, comments on flavor suggested that more panelists regarded the control patties "good" than "poor". Comment patterns also suggested that the toughness defect disappeared when soy extenders were added. At the same time, negative comments about flavor increased but numbers did not differ notably among the six extenders evaluated. In general NARADCOM consumer panel data agreed with USDA consumer panel data of Kotula et al.[5] on overall acceptability with respect to extender use levels and the effects of using TSP versus SPC.

Magnitudes and statistical significance of differences varied from withdrawal to withdrawal in addition to control sample ratings, as displayed in Appendix A, Table 5. This phenomenon has often occurred in past storage studies of subsistence items. Besides the above evidence that the control patty was not as highly acceptable as expected, consumer-type judges frequently vary in rating behavior from period to period. Condiment

[5] Kotula, A. W., G. G. Twigg, and E. P. Young, 1974. *Evaluation of frozen beef patties containing soy protein.* Technical Report 75–80–FEL. U.S. Army Natick Research & Development Command.

use patterns were highly variable and might be thought an explanation for variable rating behavior. Over the three panel sessions at each withdrawal, for example, use of catsup, relish, or both varied from a low of 30 percent of the panel to a high of 80 percent. These condiments may be considered masking agents for flavors contributed by soy extenders. However, in those sessions where usage was highest, clearcut differences between extender levels and sources resulted. The test situation may be considerably altered if a typical hamburger sandwich with a standard condiment mixture is presented to a panel. See Appendix B for a follow-up experiment to test this hypothesis.

Objective Measurements

Moisture levels in raw control and soy protein extended ground beef patties did not change during the nine months of the study as indicated by data in Appendix A, Table 7 obtained at three month intervals. As exhibited in Appendix A, Table 8, raw patty TBA values were likewise stable throughout the period of frozen storage, although a slight increase in control patty levels was observed. The relatively high variation over time in TBA values of the Swift SPC patties was not explanable from any other data obtained in this study.

Proximate and selected mineral analyses were unchanged between initial and nine-month determinations as may be seen in Appendix A, Tables 9 and 10, and 20 and 30 percent soy extender levels, respectively. Small variations in the analyses, particularly for minerals, were attributed to normal sampling and preparation error.

Mineral analyses were used in a multiple linear correlation technique in an attempt to relate their levels to percent soy solids in the raw ground beef patties. Results are given in the table below for calcium and magnesium levels which were found to be useful predictors.

Soy Extender Source	No. of Pairs	R
TSP		
Swift	16	0.9998
Pfizer	16	0.9970
Cargill	16	0.9998
ADM	16	0.9993
SPC		
Swift	16	0.9977
Central Soy	16	0.9982

Calcium and magnesium were X_1 and X_2; Y was the dependent variable, percent soy solids. Since the sample size was small, results were considered inconclusive. However,

they were sufficiently encouraging to suggest further investigation of this indirect method for determining percent soy protein in ground beef.

Shankman Laboratories B-complex vitamin analyses are given in Appendix A, Table 11. There were no substantial differences with respect to any of the B vitamin levels between the control and any of the sources, types, and levels of soy protein extenders. In the majority of determinations, there appeared to be a slight advantage in the use of extenders, since vitamin contents tended to be slightly higher. Patties containing three of the extenders at the 30 percent level were significantly higher than the control in pyridoxine content. The same occured with one of these extenders in the case of thiamine.

Appendix A, Table 12 indicates that, compared to the control, four to six percent reductions in total cooking losses were obtained when patties contained TSP or SPC extenders at the 20 percent level. When the level was 30 percent, three to ten percent additional reductions resulted. It was unclear whether the function of the soy protein extenders was to retain moisture, fat, or both. This would be a worthwhile topic for future investigations.

Table 12 also indicates that dramatic reductions in Allo-Kramer shear values occurred in cooked patties containing the extenders compared to the control. Although sensory perceptions of tenderness were not directly assessed, these objective data to a great extent corroborate the voluntary sensory panel comment summaries found in Table 6. In future investigations, direct sensory estimates of attributes such as tenderness and juiciness would be desirable. The above indirect evidence, however, was confirmed at Kotula et al. (see *reference* 5) on these same lots of patties. Their consumer panels rated the control patty significantly lower in tenderness on a tough to tender category scale.

CONCLUSIONS

1. The addition of relatively high (20 and 30 percent) levels of soy protein extenders to ground beef patties resulted in decreases in overall sensory acceptability compared to all-beef patties, as judged by a consumer-type panel. A TSP from one source emerged as significantly more acceptable then other TSP and SPC extenders investigated. Generally, acceptability of the SPC extenders was poorer than the TSP extenders, both in the average ratings across all panel sessions or in individual sessions.

2. No changes in moisture levels, fat, protein or ash level analysis occurred, compared to the control samples, either over time of storage or due to the addition of either TSP or SPC extenders. The same was true of mineral analyses and, with few exceptions, of vitamin B-complex analyses. TBA values were stable in all lots of patties over the time of the study.

3. Substantial reductions in total cooking losses and in Allo-Kramer shear values were observed with addition of both TSP and SPC extenders at the two levels studied. Thirty percent extender levels resulted in additional reductions in both objective measurements compared to the 20 percent levels.

REFERENCES

1. United States Department of Agriculture, Food and Nutrition Service, FNS Notice 219, February 1971.

2. Huffman, D. L. and W. E. Powell, 1970. *Fat content and soy level effect on tenderness of ground beef patties.* Food Technology 24:1418.

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4. Parladgis, B. G., B. M. Watts, M. T. Younathan and L. Dugan, Jr., 1960. *A distillation method for the quantitative determination of malonaldelyde in rancid foods.* J. Amer. Oil Chem. Soc., **37**:44.

5. Kotula, A. W., G. G. Twigg, and E. P. Young, 1974. *Evaluation of frozen beef patties containing soy protein.* Technical Report 75–80–FEL. U.S. Army Natick Research & Development Command.

6. Official Methods of Analysis, Association of Official Chemists, 11th ed., 1970. Washington, D.C.

APPENDIX A

TABLE 1

Calculated Soy Extender and Analyzed Fat Levels; Ground Beef-Patty Formulations

Type/Source	Calculated Rehydrated Extender (%)	Analyzed Fat in Ground Beef (%)	Patty Formulations		
			kg Ground Beef	kg Dry Extender	kg Water
Textured Soy Protein (TSP)					
Swift	20	24.8	182.8	18.1	27.2
	30	31.8	160.1	27.2	40.8
Pfizer	20	25.8	182.8	18.1	27.2
	30	28.4	160.1	27.2	40.8
Cargill	20	24.8	182.8	18.1	27.2
	30	29.6	160.1	27.2	40.8
ADM	20	24.8	182.8	18.1	27.2
	30	28.4	160.1	27.2	40.8
Soy Protein Concentrates (SPC)					
Swift	20	24.0	182.8	13.1	32.6
	30	30.6	160.1	19.5	49.0
Central Soya	20	24.8	182.8	13.1	32.6
	30	30.2	160.1	19.5	49.0
Control	0	20.8	226.8	–	–

TABLE 2

Promixate and Selected Mineral Analyses of Soy Protein Extenders

Soy Extender Source	%H_2O	% Fat	% Protein	% Ash	% NaCl	mg/100g Ca	mg/100g P	mg/100 Fe	mg/100g Na	mg/100g K
Textured Soy Protein (TSP)										
Swift	7.49	0.21	48.29	6.17	0.0	355.2	705	10.5	1	2397
Pfizer	8.96	0.29	45.38	5.96	0.0	301.3	650	8	8	2315
Cargill	9.15	0.81	45.42	6.08	0.0	323.5	741	17	17	2334
ADM	7.15	0.46	49.39	6.39	0.0	412.2	739	4	4	2339
Soy Protein Concentrates (SPC)										
Swift	7.28	0.30	58.88	3.74	0.0	357.4	779	7.1	11	600
Central Soya	9.96	0.47	58.63	5.85	0.0	414.6	775	2	2	2012

TABLE 3

Summary of Sensory Acceptance Panel Data[1]

Main Effect[2]	Number of Judgments	Mean Ratings
Soy Extender Level (%)		
0	840	6.3 ± 1.7[3]
20	840	5.7 ± 1.8
30	840	5.2 ± 2.0
Extender Source		
Textured Soy Proteins (TSP)		
ADM	420	6.1 ± 1.8
Swift	420	5.8 ± 1.9
Cargill	420	5.7 ± 1.9
Pfizer	420	5.6 ± 1.9
Soy Protein Concentrates (SPC)		
Central Soya	420	5.6 ± 1.9
Swift	420	5.6 ± 1.8
Months Storage		
0 (Initial)	630	6.0 ± 1.9[4]
3	630	5.6 ± 2.0
6	630	5.6 ± 1.8
9	630	5.7 ± 1.8

[1] The A-category hedonic scale was scored as follows: 1 = dislike extremely to 5 = neither like nor dislike to 9 = like extremely.

[2] Ratings for each variable were averaged across the other two variables.

[3] Although the main effects for level and source were significant in the analysis of variance, there was also a significant level-source interaction that nullified the main effects. The cause of the interaction was the control sample, as exhibited in Table 3.

[4] The main effect for months storage was significant. However, the source-time interaction was also significant, nullifying the main effect.

TABLE 4

Hedonic Scale Acceptance Data Recomputed Without Control Ground Beef Patty Ratings

Variable[1]	Number of Judgments	Mean[4] Ratings
Soy Extender Level (%)[2]		
20	840	5.7 ± 1.8[a]
30	840	5.2 ± 2.0[b]
Extender Source		
Textured Soy Protein (TSP)[2]		
ADM	280	5.9 ± 1.8[a]
Cargill	280	5.5 ± 1.9[b]
Swift	280	5.5 ± 2.0[b]
Pfizer	280	5.4 ± 1.9[b]
Soy Protein Concentrates		
Central Soya	280	5.3 ± 1.9[b]
Swift	280	5.2 ± 1.8[b]
Months Storage[3]		
0 (Initial)	420	5.7 ± 1.9
3	420	5.3 ± 1.9
6	420	5.4 ± 1.9
9	420	5.5 ± 1.8

[1] Ratings for each variable were averaged across the other two variables.

[2] Elimination of control sample ratings from the analysis of variance computation also eliminated the level-source interaction. Therefore, the main effects of level and source were valid. For each effect, mean ratings followed by unlike letters are significantly different, $p < 0.01$.

[3] Although the main effect was significant, the source-time interaction remained. It appeared, however, that practical differences in acceptability over storage time were inconsequential.

[4] Mean ratings in columns followed by different letters are significantly different, $p \leq 0.05$.

Table 5

Consumer-Type Hedonic Scale Ratings of Beef Patties by Session[1]

Session/Source	Soy Extender Level	Months Storage 0	3	6	9
I					
Control	0	7.0 ± 1.3	6.5 ± 1.7	6.1 ± 1.6	6.1 ± 1.5
Swift (TS)	20	5.8 ± 1.9	5.9 ± 1.7	5.5 ± 1.9	5.3 ± 2.1
Swift (TSP)	30	5.1 ± 1.9	6.1 ± 1.9	5.0 ± 2.0	4.9 ± 2.2
Swift (SPC)	20	5.9 ± 1.8	5.4 ± 1.9	5.4 ± 1.7	5.4 ± 1.6
Swift (SPC)	30	5.0 ± 2.0	4.8 ± 1.7	5.1 ± 1.8	5.3 ± 1.7
II					
Control	0	6.1 ± 2.0	5.8 ± 1.7	6.3 ± 1.3	6.1 ± 1.7
Pfizer (TSP)	20	6.3 ± 1.9	5.2 ± 1.7	5.5 ± 1.8	5.7 ± 1.5
Pfizer (RSP)	30	5.3 ± 2.0	5.0 ± 2.0	5.1 ± 2.0	4.9 ± 2.0
Cargill (TSP)	20	5.5 ± 1.9	5.5 ± 2.0	5.9 ± 1.8	5.7 ± 1.9
Cargill (TSP)	30	5.5 ± 1.9	5.3 ± 2.1	5.1 ± 2.2	5.3 ± 1.7
III					
Control	0	6.7 ± 1.7	6.3 ± 2.0	5.9 ± 2.0	6.3 ± 1.5
ADM (TSP)	20	6.5 ± 1.3	5.9 ± 1.4	5.3 ± 1.9	6.5 ± 1.4
ADM (TSP)	30	6.1 ± 1.9	5.4 ± 2.0	5.5 ± 2.1	6.3 ± 1.7
Central Soya (SPC)	20	5.4 ± 1.9	5.2 ± 2.1	5.8 ± 1.5	5.7 ± 1.6
Central Soya (SPC)	30	5.5 ± 1.6	4.1 ± 2.1	5.4 ± 2.1	5.4 ± 1.8

[1] List of statistically significant differences in acceptability ratings by session and months storage. Analysis of variance for each session at each time was followed by a Duncan Multiple range test if the F-ratio was significant. $P \leqslant 0.05$.

Session I

0 Months: Control higher than all. Twenty percent levels higher than 30 percent levels.

3 Months: Control and 30 percent level Swift TSP higher than both levels of Swift SPC.

6 Months: Control and 20 percent Swift TSP higher than 30 percent levels of both extenders.

TABLE 5

Consumer-Type Hedonic Scale Ratings of Beef Patties by Session (cont'd)

Session I (cont'd)

9 Months: Control higher than all others. Twenty percent levels of both TSP and SPC higher than 30 percent level of SPC.

Session II

0 Months: Control higher than 30 percent level of Pfizer TSP. Twenty percent Pfizer TSP higher than 30 percent level of same and both levels Cargill TSP.

3 Months: No differences

6 Months: Control and 20 percent Cargill TSP higher than 30 percent levels of both extenders.

9 Months: Control higher than 30 percent levels of both extenders. Twenty percent higher than 30 percent level of Pfizer TSP.

Session III

0 Months: Control and both levels ADM TSP higher than both levels of Central Soya SPC.

3 Months: Control higher than both levels of Central Soya SPC and 30 percent level of ADM TSP. All rated higher than 20 percent Central Soya SPC.

6 Months: No differences

9 Months: Control and both levels of ADM TSP higher than both levels of Central Soya SPC.

TABLE 6

Average Numbers of Positive (Pos) and Negative (Neg) Voluntary Comments Made by Consumer Sensory Panels About Ground Beef Patties With and Without Soy Protein Extenders

Main Effect	Flavor[1]		Textures[1]	
	Pos[4]	Neg[5]	Pos[4]	Neg[6]
Percent Soy Extender Level[2]				
0 (Control)	5	3	1	14
20	2	7	2	4
30	1	12	6	2
Soy Protein Source[3]				
Archer Daniels (ADM) TSP	4	9	3	1
Swift Texgran TSP	2	9	2	1
Cargill TSP	2	10	4	2
Pfizer TSP	2	9	3	3
Swift Concentrate SPC	2	7	1	5
Central Soya SPC	2	7	1	4
Storage Time				
Initial, 0 months				
0% Soy (Control)	6	2	3	13
20% Soy	3	7	2	3
30% Soy	2	9	3	2
3 Months				
0% Soy (Control)	5	4	0	14
20% Soy	2	4	1	5
30% Soy	1	11	1	2
6 Months				
0% Soy (Control)	4	3	1	13
20% Soy	4	4	1	2
30% Soy	2	9	2	1
9 Months				
0 Soy (Control)	4	3	1	14
20% Soy	2	8	3	4
30% Soy	1	12	5	2

[1] 35 panelists per session.

[2] Comments about control sample are averaged from 12 trials. Those for 20 and 30 percent levels are computed from 24 trials (6 sources x 4 withdrawals).

[3] Averages of 20 and 30 percent extender levels over four withdrawals.

[4] Most frequent comment was the evaluative word "good".

[5] Most frequent comment was the evaluative word "poor". Other Comments described "flavor lacking" or "greasy". A few "cereal added" comments were also made.

[6] Most frequent comment about the control described "toughness' or "rubberiness"; few similar comments were made about patties with soy extenders. Most frequent comment about extender added patties was "dryness".

TABLE 7

Percent Moisture in Stored Ground Beef Patties at Two Levels of Soy Extender Addition[1]

Soy Extender Source	Level Added	Months Storage at -18°C 0	3	6	9
Control	0	59.7	59.5	59.2	58.0
Textured Soy Proteins (TSP)					
Swift	20	57.4	57.5	56.3	57.7
	30	53.5	55.5	56.1	56.0
Pfizer	20	57.2	56.3	55.6	56.3
	30	56.8	55.9	56.7	
Cargill	20	57.8	57.7	58.5	58.6
	30	56.3	55.8	55.9	57.1
ADM	20	56.7	56.5	55.5	56.0
	30	58.9	56.0	55.1	55.4
Soy Protein Concentrates (SPC)					
Swift	20	59.6	58.3	59.3	59.7
	30	61.1	60.1	60.4	60.2
Central Soya	20	58.6	58.5	58.8	58.0
	30	59.3	57.9	58.2	59.2

[1] AOAC procedure (see reference 6)

TABLE 8

Thiobarbituric Acid (TBA) Index of Rancidity in Stored Raw Ground Beef Patties With Two Levels of Added Soy Protein Extenders[1]

Soy Extender Source	Level Added	Months Storage at -18°C 0	3	6	9
Control	0	1.2	3.3	5.4	3.7
Textured Soy Proteins (TSP)					
Swift	20	0.7	1.1	1.0	0.8
	30	1.1	2.0	1.4	0.9
Pfizer	20	0.9	1.3	1.3	1.3
	30	0.7	1.0	1.0	0.9
Cargill	20	0.4	0.5	0.8	0.7
	30	0.2	0.5	0.3	0.5
ADM	20	0.5	1.5	1.5	1.5
	30	1.3	0.9	0.6	0.5
Soy Protein Concentrates (SPC)					
Swift	20	1.4	2.7	5.7	2.3
	30	1.6	10.3	7.5	3.5
Central Soya	20	1.2	1.6	1.4	1.4
	30	1.2	0.8	1.2	0.9

[1] Procedure described by Parladgis et al., 1960 (see reference 4).

TABLE 9

Proximate and Selected Mineral Analyses of Raw Ground Beef Patties Containing 20 Percent Soy Protein Extenders[1]

Brand of Soy Protein	Months Storage at -18°C	% H_2O	% Fat	% Prot.	% Ash	% NaCl	mg/100g Ca	mg/100g P	mg/100g Fe	mg/100g Na	mg/100g K	mg/100g Mg
Control	0	59.7	21.8	17.1	0.8	0.2	8.0	139.4	1.9	71.8	286.4	16.3
	9	58.0	23.9	17.4	0.9	0.1	5.9	152.2	2.0	74.2	303.8	17.0
Textured Soy Proteins (TSP)												
Swift	0	57.4	22.3	16.5	1.1	0.1	34.3	162.0	2.4	65.4	393.0	35.6
	9	57.7	20.6	17.5	1.2	0.1	24.1	175.0	2.7	59.8	468.0	40.7
Pfizer	0	57.2	23.7	16.5	1.0	0.2	28.1	149.2	2.5	76.8	377.8	29.3
	9	56.3	24.6	16.2	1.1	0.1	16.3	157.6	2.6	69.6	393.2	30.1
Cargill	0	57.8	22.2	17.1	1.1	0.1	32.2	164.4	2.3	72.2	405.8	35.8
	9	58.6	20.9	17.3	1.2	0.1	18.2	177.6	2.4	65.0	439.6	35.3
ADM	0	56.7	22.2	17.3	1.2	0.1	39.2	162.6	2.4	68.8	426.0	38.0
	9	56.0	24.5	17.6	1.1	0.1	19.8	167.2	2.4	65.0	421.2	32.9
Soy Protein Concentrates (SPC)												
Swift	0	59.6	21.8	16.4	0.8	0.1	27.8	160.6	2.3	75.6	258.8	20.3
	9	59.7	21.3	17.1	0.8	0.1	15.8	164.4	2.4	61.8	285.0	19.4
Central Soya	0	58.6	23.0	16.4	1.0	0.1	31.3	146.4	2.6	70.6	351.8	32.9
	9	58.0	23.9	16.5	1.0	0.1	19.5	154.4	2.6	63.6	361.0	29.8

[1] AOAC procedures used for all analyses (see reference 6).

TABLE 10

Proximate and Selected Mineral Analyses of Raw Ground Beef Patties Containing 30 Percent Soy Protein Extenders[1]

Brand of Soy Protein	Months Storage at -18°C	% H_2O	% Fat	% Prot.	% Ash	% NaCl	mg/100g Ca	mg/100g P	mg/100g Fe	mg/100g Na	mg/100g K	mg/100g Mg
Control	0	59.7	21.8	17.1	0.8	0.2	8.0	139.4	1.9	71.8	286.4	16.3
	9	58.0	23.9	17.4	0.9	0.1	5.9	152.2	2.0	74.2	303.8	17.0
Texture Soy Proteins (TSP)												
Swift	0	53.5	27.7	15.4	1.1	0.2	39.8	149.4	2.3	73.8	384.4	36.9
	9	56.0	21.7	17.6	1.3	0.1	29.8	179.6	2.5	59.8	504.2	47.1
Pfizer	0	56.8	22.0	16.7	1.2s	0.2	45.6	166.0	3.1	63.0	449.0	42.8
	9	56.7	22.4	16.4	1.2s	0.1	26.0	171.2	3.1	57.2	462.6	40.4
Cargill	0	56.3	23.0	16.5	1.3	0.2	44.3	171.8	2.1	61.8	470.6	46.4
	9	57.1	21.7	16.3	1.3	0.1	24.5	182.8	2.3	57.0	509.6	43.1
ADM	0	58.9	22.2	16.3	1.1	0.1	42.8	150.0	2.6	56.4	351.0	37.6
	9	55.4	22.0	16.9	1.3	0.1	33.1	182.2	2.4	53.8	510.6	46.1
Soy Protein Concentrates (SPC)												
Swift	0	61.1	19.2	16.7	0.9	0.1	35.7	169.4	2.7	63.8	255.4	24.1
	9	60.2	19.6	17.2	0.9	0.1	23.3	179.6	2.7	57.0	261.4	23.0
Central Soya	0	59.3	21.7	15.9	1.0	0.1	41.7	148.0	2.6	56.6	357.6	38.6
	9	59.2	22.1	16.3	1.0	0.1	25.2	158.6	2.6	52.6	385.0	35.9

[1] AOAC procedures used for all analyses (see reference 6)

TABLE 11

Vitamin B Complex Levels in Ground Beef Patties Containing Soy Protein Extenders[1]

Source	Level %	Thiamine[2]	Riboflavin	Niacin	Pyridoxine[2]	Vitamin B_{12}
Control	0	0.045 ± 0.033	0.186 ± 0.036	3.6 ± 0.41	0.202 ± 0.052	2.45
Textured Soy Proteins (TSP)						
Swift	20	0.068 ± 0.040	0.169 ± 0.027	3.2 ± 0.76	0.188 ± 0.012	2.14
	30	0.078 ± 0.043	0.168 ± 0.022	3.4 ± 0.22	0.191 ± 0.019	1.98
Pfizer	20	0.078 ± 0.047	0.193 ± 0.024	4.0 ± 0.38	0.218 ± 0.026	2.30
	30	0.141[a] ± 0.066	0.217 ± 0.034	4.6 ± 0.49	0.308[a] ± 0.051	2.50
Cargill	20	0.061 ± 0.042	0.207 ± 0.042	4.6 ± 0.53	0.270 ± 0.034	2.12
	30	0.063 ± 0.042	0.211 ± 0.044	4.2 ± 0.54	0.285[a] ± 0.045	2.62
ADM	20	0.059 ± 0.042	0.212 ± 0.033	3.8 ± 0.65	0.219 ± 0.022	2.05
	30	0.66 ± 0.038	0.277 ± 0.019	4.4 ± 0.48	0.233 ± 0.025	2.45
,Soy Protein Concentrates (SPC)						
Swift	20	0.050 ± 0.033	0.172 ± 0.016	3.7 ± 0.30	0.218 ± 0.030	1.60
	30	0.065 ± 0.039	0.186 ± 0.026	3.8 ± 0.39	0.194 ± 0.018	1.85

TABLE 11

Vitamin B Complex Levels in Ground Beef Patties Containing Soy Protein Extenders[1] (Cont'd)

Source	Level %	Thiamine[2]	Riboflavin	Niacin	Pyridoxine[2]	Vitamin B_{12}
Soy Protein Concentrates (SPC) (cont'd)						
Central Soya	20	0.046 ± 0.028	0.191 ± 0.028	4.2 ± 0.36	0.247 ± 0.042	2.53
	30	0.056 ± 0.043	0.204 ± 0.028	3.8 ± 0.78	0.312[a] ± 0.042	2.60

[1] Averages represent at least 10 determinations for all but vitamin B_{12} which were at least 2 determinations. All values are reported as mg/100gms.

[2] The superscript "a" indicates the level was significantly higher than found in the control sample as determined by the analysis of varience, $p < 0.05$.

TABLE 12

Total Cooking Losses and Allo-Kramer Shear Values for Ground Beef Patties Containing Two Levels of Soy Protein Extenders[1]

Source	Level (%)	Cooking Loss[2] (%)	Shear Values[3]
Control	0	36.8 ± 1.2	1837 ± 37.9
Textured Soy Proteins (TSP)			
	20	26.2 ± 1.2	1228 ± 22.9
	30	22.8 ± 1.2	1165 ± 20.9
Pfizer	20	32.4 ± 0.7	1443 ± 27.4
	30	27.3 ± 1.1	1183 ± 22.4
Cargill	20	27.9 ± 1.6	1385 ± 18.2
	30	26.9 ± 1.4	1241 ± 16.4
ADM	20	30.3 ± 1.1	1430 ± 36.6
	30	23.4 ± 1.1	1022 ± 17.2
Soy Protein Concentrates (SPC)			
Swift	20	32.0 ± 1.2	1524 ± 38.2
	30	26.4 ± 1.8	1134 ± 27.2
Central Soya	20	32.9 ± 2.3	1295 ± 21.0
	30	29.2 ± 2.1	1044 ± 14.7

[1] Each value is the average of determinations on 20 randomly selected patties from each lot.

[2] Percent Total Cooking Loss = $\frac{\text{Frozen Weight} - \text{Cooked Weight}}{\text{Frozen Weight}} \times 100$

[3] Units are newtons required to shear cooked patties of approximately 1.3 cm thickness.

APPENDIX B

TEST OF CONTROL AND SELECTED SOY PROTEIN EXTENDED GROUND BEEF PATTIES IN BUNS WITH CONDIMENTS

Rationale. Following the six-month storage test (the third series of acceptance evaluations), it was evident that one TSP was consistently performing about as well as the control patty and others, particularly SPC extenders, were consistently poor performers. The question arose whether or not consumer judges would react differently to the presence of the soy ingredients in ground beef patties if they were served in a manner typical of many fast food franchises, i.e., in a bun with a controlled use level of a "standard condiment mixture".

Method. A five-sample test was set up. Included in the test was the control patty and both use levels of the most acceptable TSP, the ADM, and least acceptable SPC extenders, the Swift. As in the main experiment, patties were grilled as needed for serving to a 35-member consumer panel. After grilling, they were placed in previously warmed standard white buns. The sandwiches were then cut in half and placed in pans in an 83°C bain marie for holding. Just before serving, one tablespoon (about 25 grams) of a condiment mixture was added per half sandwich and spread evenly. The mixture consisted of one part mustard, one part sweet pickle relish, and four parts catsup. Panelists gave overall hedonic ratings as before.

Results. No significant differences in acceptability were found as displayed in the following table.

Sample		Hedonic Mean
Control		6.5 ± 1.4
ADM	20% level	6.5 ± 1.3
ADM	30% level	6.3 ± 1.7
Swift	20% level	6.3 ± 1.6
Swift	30% level	6.3 ± 1.5

The use of a bun and condiments did not increase acceptability of the Control. Ratings, however, did suggest that the effects of soy protein additions were masked. Nevertheless, there was some evidence through voluntary comments that (1) the negative texture characteristics of the Control patty continued to be noticed – nearly 33% of the panel observed "poor" or "dry" texture and (2) the undesirable flavor characteristics of the soy added patties were still observed – although not as frequently as when they were served plain; these were offset by equivalent numbers of "good flavor" comments.

Conclusion. The experiment demonstrated that the presence of soy protein extenders can be masked. Nevertheless, the experimental approach in this study was appropriate because: (1) soy protein extenders investigated represented different sources; (2) this may lead to variations in the degree to which they affect flavor of ground beef; (3) the most sensitive test situation was required to measure acceptability; and (4) in military food service systems, condiment usage is optional although most ground beef patties are consumerd in buns.

A survey of NARADCOM consumer panelists prior to the main study revealed that about 50 percent used one or more condiments; the other 50 percent used salt only or used nothing on their "hamburgers", During the panel sessions, actual use of condiments varied, as already noted. These data suggested, however, that a significant consumer segment may exist, both military and civilian, who do not use condiments. These individuals may be more likely to complain about soy protein extended ground beef patties. In the future, soy refining processes may be improved to the point that the use levels investigated in this study produce little, if any, alteration in ground beef flavor.

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